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ISOMORPHOUS SUBSTITUTION OF ELEMENTS IN MINERALS*

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The fact that certain elements could substitute for others in chemical compounds was known for some time before the concept was introduced into mineralogy and chemistry. Mitscherlich, during his chemical work on the salts of arsenic and phosphoric acids in 1819, noted that crystals of corresponding salts of these acids resembled each other very closely in habit and angles and, not having at that time the means of accurate measurement, he believed that they were identical. In 1821 he introduced the term "isomorphism" in mineralogy, with the following explanation: "An equal number of atoms similarly combined produce the same crystal form, independent of the nature of the atoms but determined by their relative position."

Previous to this, in 1811, Haüy announced that each chemically pure substance, when crystalline, possessed its own characteristic angle, which has since been proven one of the fundamental laws of crystallography. This was opposed to the conception of Mitscherlich, as in his opinion isomorphous substances possessed identical angles.

The controversy following these opposing views was not settled for years, but was materially allayed by Wollaston who, having invented the reflecting goniometer in 1812, announced that the orthorhombic sulphates and carbonates of barium, strontium and lead showed consistent measurable differences, though these differences were small. The enormous mass of data accumulating since reaches much farther, and adds that the angles in isomorphous groups are a function of the chemical composition.

Thus the law of isomorphism was narrowly restricted to those

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chemical compounds with like number of atoms and configuration; but, restricted as it was, it served, in the hands of chemists, as a reliable means of deciding in some cases between combining weight and atomic weight. It was also rated by Mendeléeff as one of four exact guides or indices used by him in the construction of the table of the elements which bears his name and has stood the test of time for the last sixty years.

At the close of the nineteenth century, all the possible types of symmetry and homogeneous point-systems, after which crystals could be constructed, were mathematically determined. However, those individuals with the most active imagination did not believe it would ever become possible to measure the distance between the atoms in these point-systems; but with the advent of Laue's photographs, the determination of the length of the x-ray wave, the modifications of the Braggs, and the interest of many other workers, the point-systems have been proven to be in reality facts and not theory. We are able at the present time to put our finger on any atom in the crystal structure of a chemical compound; possibly not with complete exactness in the case of complex molecules, but certainly with full confidence in the case of the more simple. This knowledge has changed in several ways our conception of crystal structure. Mendeléeff considered the molecular volume, the result of dividing the molecular weight by density, or a multiple, as the unit of structure, or the brick used in the crystal building.

When the space relations of the atoms in halite, a simple chemical compound, are considered, where these relations are known with exactness, molecular boundaries at once fade away. Each chlorine atom is equidistant from six sodium atoms, and each sodium atom is equidistant from six chlorine atoms. There is no unique atom among the six with which to tie a chlorine atom representing the chemical formula, NaCl, although atoms are found in the crystal in the correct proportions as represented by the chemical formula. This is true of most mineral crystals and valance relations, as known in many organic compounds, liquids and gases, are lost. The ionic forces still remain, but apparently with quite a different distribution, as in sodium chloride the single valence of chlorine has no choice between six sodium ions, but from point of view of distance must necessarily be equally attracted by each.

For convenience in description and comparison, an imaginary

crystalline unit has developed, which was defined by the Braggs in the following manner: "The unit of cell structure is the smallest portion of a crystal which, repeated through space without change in character or orientation, makes up the crystal." All atoms and bonds in the proportions required by the chemical formula will be contained in the unit, as well as all physical properties and symmetry of the crystal will be represented. The crystal is constructed by simply placing one unit beside another, as the bricks in a wall. It is within this unit of structure that isomorphous elements are substituted, and the resulting modifications of volume, angles and all other physical properties are the resultant or summation of forces interacting within the unit. These forces are both attractive and repulsive, polar and non-polar; and the internal space arrangement of atoms in the unit is the resultant or equilibrium attained by these interactions and may be modified by temperature and pressure. The attraction between atoms, which has become known as Van der Waal's cohesive force, and the electrostatic forces due to valence ionization, are the determinative forces in the growth of a crystal, and of these Leonard-Jones and Dent[1] say that "the Van der Waal field falls off according to a second or third power of the distance and so becomes of greater importance than the electrostatic at a long distance" and suggests that Van der Waal's forces act as the first agent in the process of capturing atoms at the surface of growing crystals, and the electrostatic force clinches the capture and fixes the atom in the crystal and presumably the relation in the crystal unit. The distance between pairs of atoms of any two elements, as measured in crystals, varies with the compounds, the pressure with which they are forced together depending upon their chemical affinity and valence. Gibbs believed that this distance varied with the binding forces and was inversely proportionate to the valence. The combining radius of an atom varies when measured in compounds of quite different chemical character; and whether the atoms or ions fill space or not, their relative positions represent equilibrium, or the resultant of attractive and repulsive forces interacting between them. In sodium chloride, where the valence of chlorine is one and sodium also one, each chlorine atom is equidistant from six sodium atoms in the direction of the cubic faces, and the field of influence or domain is usually considered as a sphere with six flattened facets parallel to the cube, or six areas

[1] Leonard-Jones and Dent, *Trans. Faraday Soc.*, vol. **24**, p. 92, 1928.

in common to the sodium and chlorine atom. Whether this represents the atom of an element or its reaction limits is immaterial. The pressure areas will increase in size with the increase of pressure.

In the case of an individual atom, surrounded by neighbors in the network exerting various pressures, the original sphere will be distorted and the resultant lines of force will vary and thus become directional, a characteristic of the physical property of crystals. The atom reacting under the varied pressures as a loosely inflated ball, its radius of combination changes in direction with pressure, both shape and volume depending on the co-ordinate number of its positions within the crystal unit. Bragg[2] notes that the interatomic distance between oxygen atoms in the silicate may vary from 2.5 to 2.9Å according to their position, leading to a considerable variation in volume. If this be true, then atoms of the same elements in a crystal are not by any means surrounded by the identical conditions in regard to space and interacting forces. In one position the atom may be replaced with ease, while in another with great difficulty, if at all. In forsterite Mg_2SiO_4, of the olivine group, there are two positions of magnesium atoms, an equal number of each. One set lies at a center of symmetry, sharing a pair of oxygen atoms with two tetrahedra; and the other set, with only one tetrahedron.[3] In the crystal structure of monticellite[4] $(MgCa)SiO_4$, the isomorphous calcium atom has been substituted for one set of magnesium atoms, without changes in symmetry but with increase of cell dimensions due to the greater atomic diameter of calcium. It would be interesting to know which set of magnesium atoms have been displaced; whether it is the same set in which ferrous iron is substituted to form olivine or whether, due to the smaller size of the iron, it is the other set which is displaced; indicating that the two sets of magnesium atoms are quite different in their isomorphous tendencies.

In this same unit structure of Mg_2SiO_4, (4 to the unit,) there are three positions of oxygen atoms, which would also possibly represent three degrees of isomorphism, if there were any elements capable of being substituted for oxygen in this structure. Warren[5] in his work on the crystal structure of tremolite points out that

[2] Bragg, W. L., *Zeit. Krist.*, vol. **74**, 278, 1930.

[3] Bragg, W. L., *Zeit. Krist.*, vol. **74**, 241, 1930.

[4] Brown, G., and West, J., *Zeit. Krist.*, vol. **66**, 154, 1927.

[5] Warren, B. E., *Zeit. Krist.*, vol. **72**, 42 and 493, 1930.

the chemical formula should be $H_2Ca_2Mg_5(SiO_3)_8$, with two molecules in the crystalline unit. Eight magnesium atoms are similarly located in the crystalline lattice; but two atoms, or one in each chemical molecule, hold an unique position. Berman and Larsen[6], in their study of a hundred analyses of alkali amphiboles, have reported that in the substitution of isomorphous atoms for magnesium there is always one of the five magnesium atoms remaining and not displaced. It is natural to conclude that this is the unique atom, and that it is able to hold its position against all applicants is due to the ionic attractions surrounding it, or to its co-ordinate position. They also point out other limited substitutions; as aluminum never substitutes for more than two atoms of silicon. A possible explanation of this is that an atom of aluminum coupled with an atom of sodium replaces a silicon atom, the sodium occupying the vacant place in Warren's lattice of the amphiboles.

Radii or Volume of Atoms

Undoubtedly atoms of equal volume or radii, or more particularly of equal domain, have a great tendency to substitute for each other, and especially so when the isomorphous minerals contain the same number of atoms and the same configuration in the lattice. If the volume were exactly equal, this would amount to the same as taking a brick out of a wall and slipping in another of the same size but of different material and color. But all atoms are not of the same volume, as is shown by Wherry's[7] table of atomic volumes. Following the principles expressed by Wherry[8], we would expect sodium and magnesium, differing in radii by .05Å, to substitute for each other under most varied conditions; but the experience is that calcium and sodium change places more often, differing in radii by .25Å.

If the historically noted isomorphous group of rhombohedral carbonates is considered, calcium, with an atomic radius of 1.75Å and a volume of 22.4, differs considerably from iron with a radius of 1.30Å and volume 9.2, and from manganese, lying next to calcium, with a radius of 1.50Å and a volume of 14.9; nearly three times the volume in one case and double in the other. There must certainly be other compensatory factors or variables to allow this substitu-

[6] Berman, Harry, and Larsen, E. S., *Am. Mineral.*, vol. **16**, 140, 1931.

[7] Wherry, E. T., *Am. Mineral.*, vol. **9**, 165, 1924.

[8] Wherry, E. T., *Am. Mineral.*, vol. **8**, 1, 1923.

tion and not at the same time change the symmetry of the type. The lattice of the calcite atoms is the face centered rhombohedron in which the three oxygen atoms[9] are not definitely fixed, but are symmetrically arranged around the trigonal axis and may be moved back and forth along this axis, or farther away from it in the basal plane, without affecting the symmetry, thus introducing a compensation for the variable volume of entering isomorphous atoms.[10] The sulphur atoms in pyrites are also movable on the trigonal axis in a like manner. Other examples have been noted, enough in fact to form an important group when considered from the isomorphous point of view.

In the space-lattice of crystals where all units of structure are identical, or in other words where no isomorphous atoms have been substituted, the structure is supposed to be at equilibrium and without strain. In the substitution of isomorphous atoms a strain is immediately set up in the structure which increases with the percentage of substitution. In the isometric system this strain is indicated by a linear change of the cubic edge. In types of lower symmetry, it is indicated by variation of angular change as well. Linear changes in the substitution of manganese for calcium in the above carbonate series represents an ideal pair where complete substitution may take place from either end without change in symmetry. In the same substitution, where the larger atom of calcite has taken the place of a smaller atom of manganese, there is a continuous increase of the space between the rhombohedral planes, from 2.85Å[11] in rhodochrosite to 3.075Å in calcite, and an increase of the rhombohedral angle of from 73° to 74° 55′. At the same time the oxygen atoms have moved farther away from the center of the larger calcium atom as well as from the carbon atom.

In the substitution of calcium for magnesium and vice versa, the strains become so great that when the proportion of 1:1 is reached a change of symmetry takes place and a new phase, dolomite appears. Also, as reported by Pabst[12], in the case of gold crystallizing in the isometric close-pact atoms with an atomic radius of 1.45Å, and mercury crystallizing in the hexagonal nearly close-pact atoms with an atomic radius of 1.60Å, the mercury enters the gold

[9] *Phil. Mag.*, ser. 6, vol. **40,** 169, 1920.

[10] Wyckoff, R. G. W., *Am. Jour. Sci.*, 4th Series, vol. **50,** 317, 1920.

[11] Krieger, Philip, *Am. Mineral.*, vol. **15,** 23, 1930.

[12] Pabst, Adolf, *Z. Physik., Chem.*, abt. B, vol. **3,** 443, 1929.

lattice up to 15 per cent, but somewhere between that and 20 per cent the symmetry changes to the hexagonal symmetry of mercury. Aluminum and zinc are a similar pair. Zinc, with an atomic radius of 1.40Å and a hexagonal symmetry, enters the alumimum (atomic radius 1.35Å but with an isometric symmetry) lattice to the amount of 15 atomic per cent.[13] The rigidity of the aluminum lattice resists further stress and substitution ceases leading to limited isomorphism, though the radii are very close in size but differ in directional forces; while two metals, silver and gold, with the same difference of atomic radii .05Å but with like symmetry, substitute for each other from end to end. Copper and nickel, both isometric but with a difference of .25, form a complete series.

The compressibility of solid elements and its bearing on isomorphism has been emphasized by Richards[14] and illustrated by a curve which follows very closely the atomic volume curve of Lochar Meyer, indicating very strikingly that the elements having large atomic volume are more highly compressible; since the forces surrounding an atom in a crystal may be considered as pressures of considerable magnitude their results will be quite different on atoms differing in volume.

This variable compressibility of the elements must be considered as a factor in isomorphism which enables the atom to adjust itself, not only to the space to be occupied in a given lattice, but also to the irregularities of such space. These irregularities will depend upon the co-ordinate number of the position. The greatest encroachment on, or flattening of, the atomic domain of the substitute will be in the direction of the greatest force; and with pressures from all sides it would, therefore, seem that large interatomic spaces cannot exist in the crystalline lattice not dominated by the surrounding atoms; and in cases where an element is found by analysis to be present in excess of the proportion required by the chemical formula, it probably exists by reason of discontinuities of the crystalline lattice, and therefore must be of the nature of inclusions, often submicroscopic, as a product of exsolution.

Temperature

Temperature is still another controlling agent in the substitution of atoms in the crystalline lattice. In the rise of temperature

[13] Rosenhein, Walter, *Trans. A.I.M. & M.E.*, vol. **59,** 1.

[14] Richards, T. W., *Trans. Faraday Soc.*, vol. **24,** 111, 1928.

the binding forces are gradually overcome until the structure either changes in symmetry, by unequal expansion or contraction, and a new crystalline phase occurs; as in the case of leucite, and β phases of various minerals as quartz; the orthorhombic Ag_2S, acanthite, becomes isometric argentite above 180° or it breaks down entirely at the fusing point.

It would be perfectly natural to expect two elements, as aluminum and ferric iron, with atoms of almost the same volume, with chemical properties so nearly alike that it is almost impossible to separate them quantitatively, same valence, crystallizing with the same symmetry both as elements and as oxides, to be isomorphic in their simple compounds; and it has been generally urged in the past that atoms, not isomorphous to any great extent in simple compounds, may become so in more complex compounds, by reason of the greater chances of readjusting the interacting forces. We would expect, therefore, to find in nature a feldspar in which ferric iron has substituted for aluminum to a considerable extent, but this substitution is exceedingly rare. However, D. Beliankin[15] has reported an orthoclase from Madagascar with considerable ferric iron in the crystalline lattice; but usually the pink or red orthoclases are colored by inclusions of hematite, the ferric oxide entering the lattice at high temperatures, due to the weakening of the crystalline forces, and even then only to the amount of 2 or 3 per cent, becoming metastable on cooling, with the iron finally forced out as inclusions.

Probably the best example of isomorphism at higher temperatures is that of orthoclase ($KAlSi_3O_8$) and albite ($NaAlSi_3O_8$), which form a single homogeneous lattice, probably in all proportions at 1050°C, separating in the well known perthites on cooling, where each component is a limited isomorphous crystal of the two silicates. The structure of perthite may be so fine and intimately mixed as not to be recognizable with the microscope, or submicroscopic. In such cases the complex nature becoming apparent only after application of x-ray methods, Kozu and Endo[16] found that in moonstones from Ceylon and Korea, the Laue spots were peculiarly double at ordinary temperature, which they interpreted as indicating two lattices, one representing orthoclase and the other albite. Upon heating these specimens at 500°, one set of spots began to ap-

[15] Beliankin, D., *Bull. Ac. Sci., U.S.S.R.*, 571, 1929.

[16] Kozu and Endo, *Sci. Rep. Tohoku Univ., Sendai*, 3d ser., vol. **1**, 1, 1921–1923.

proach the other; and at 1060° only one set remained, and the specimen represented one homogeneous lattice. On cooling, the lattices separated and, at 700°, again reverted to their original position with double spots.

Perthitic structures occur in groups of minerals other than feldspars. If the same interpretation is applied, they represent isomorphism at higher temperatures and separate as mixtures at lower temperatures.

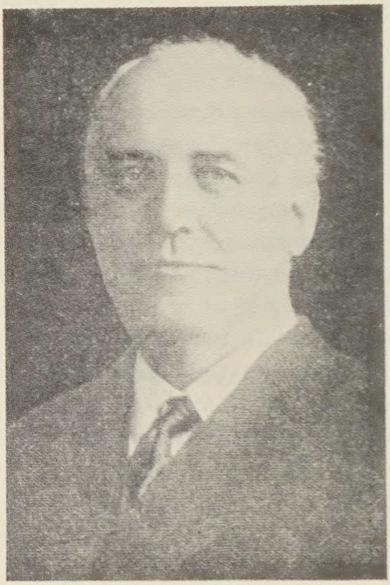
Conclusion

Undoubtedly volume is a prime factor in isomorphism, but I have attempted to show that there are other factors of equal importance even where the atoms are practically of the same size, such as (1) the coordinate position of the atom in the crystalline lattice; (2) atomic directional forces probably due to pressure; (3) the variable compressibility of the atoms; (4) differential expansion of the atoms with a rise of temperature; and lastly (5) the weakening of the crystalline forces with a rise of temperature. Many additional illustrations could have been noted justifying the assumed complex nature of isomorphism which, however, would only tend to exhaust your patience and add but little strength to the thesis.

MEMORIAL OF ARTHUR STARR EAKLE

W. T. Schaller, *U. S. Geological Survey.*

Arthur Starr Eakle, President of our Society in 1925, suddenly passed away at the St. Francis Hospital in Honolulu at 5:30 a.m., July 5, 1931, from pneumonia, resulting from a mild attack of influenza contracted the month previous. Only shortly before he had



Arthur Starr Eakle
1862–1931

retired from his Professorship at the University of California and had gone to Honolulu for a well deserved rest after nearly 30 years of teaching at Berkeley. It had been his plan to spend his remaining years in Washington, D. C., where he was born on July 27, 1862, and where many of his former students have located.

His friendly smile and lovable character endeared him to all. His graciousness and unfailing kindness, always tempered with sound advice, in no small way influenced the present writer—his first student at Berkeley to make mineralogy his life work—to likewise follow the fascinating study of minerals. One of his out-

standing characteristics was the great interest with which he followed the later progress of his students, whether they pursued mineralogy or not. He was able to recognize them at sight years after they had left his tutelage. Dr. Eakle's earnest desire to popularize mineralogy and to increase the interest in it formed the subject of his Presidential address delivered at New Haven in 1925.

Graduating at Cornell in 1892, where he was induced to take up mineralogy and petrography by Kemp, he obtained his doctorate under Groth at Munich in 1896, being a co-student there with Palache and Jaggar. He taught at Cornell and at Harvard before coming to California.

Crystal measurement and the subsequent interpretation and illustration in crystal drawings always interested him greatly and his extreme accuracy in such measurements is well attested by A. Hutchinson of Cambridge, England, who wrote (on neocolemanite) that his angular relations were: "valuable testimony to the accuracy of Eakle's goniometric observations." The crystallographical data Eakle accumulated for many minerals still serve as standards. He was one of the pioneers in the introduction of two-circle measurement and calculation in this country and his paper on the crystallography of colemanite contained so lucid an exposition of the method that it has been copied in a well known textbook.

His contributions are marked by a high standard of excellence and he is the author of: "Mineral Tables for the Determination of Minerals by Their Physical Properties" and "The Minerals of California." He described the new minerals: erionite, esmeraldaite, palacheite, neocolemanite, vonsenite, wilkeite, jurupaite, foshagite, crestmoreite, riversideite, and probertite.

Several of his students now hold Professorships in different universities and many have held important positions in the Government service at Washington.

He is survived by his widow, Fanny Kinney Eakle; a daughter, Mrs. Ronald Long, both living in Berkeley; his sister, Miss Etta B. Eakle, and brother, George H. Eakle, of Washington, D.C.

GADOLINITE FROM LOUGHBOROUGH TOWNSHIP, FRONTENAC CO., ONTARIO

H. V. Ellsworth*

Several years ago a pegmatite dike on lot 11, con. IX of Loughborough Tp., Frontenac Co., was worked a short time for feldspar by the M. J. O'Brien interests, the feldspar being shipped from Perth Road Station on the Canadian National Railway. Mr. N. B. Davis who was in charge of the operations collected from this dike a few small specimens of euxenite and part of a crystal which subsequently proved to be gadolinite. No more of this material was found and operations ceased soon afterwards. Mr. Davis states that the dike was of the ordinary type mined for feldspar in this region, with no specially noteworthy features.

The gadolinite specimen weighs about a quarter pound. It appears to be a part of the end of a good sized crystal with rough but distinct faces deformed by contact with the matrix minerals and it is well preserved, being hard and in part very fresh and vitreous. Along some small fractures the mineral is dull and grayish, and this gray substance was at first taken to be some other mineral but on optical examination of a thin section it appears to be possibly an alteration of the vitreous material. Both parts appear to have an almost equal hardness of 6.5 or more, though the vitreous material may be slightly harder than the other. The vitreous material in small grains is clear and transparent like glass under the microscope, with very perfect conchoidal fracture, anisotropic character and index greater than 1.75. There is no sign of cleavage. In the hand specimen this material is black and vitreous. The grayish material under the microscope is somewhat cloudy but largely anisotropic also. It appears to be merely a less pure and less perfectly crystallized form of the other, or perhaps is the same material somewhat altered.

Before the blowpipe a fragment of standard size does not fuse, decrepitate, or swell up. The gray part becomes a dull white and the vitreous part takes on a greenish gray color, retaining its transparency to a great degree. A very thin splinter intensely heated in the blast becomes white and porcelainic, but does not show the least indication of incipient fusion. The powdered min-

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eral is slowly decomposed by hot mineral acids but without gelatinization. The specific gravity of the selected material used for analysis was 4.101 at 18.80°C.

It may be noted that this mineral seems to differ somewhat in some of its reactions from the typical gadolinites of mineralogical literature. Nevertheless, the chemical analysis indicates nothing unusual in its composition which agrees with that of many previously described occurrences.

An analysis of selected material yielded the following results:—

Gadolinite, Loughborough tp., Frontenac Co., Ont.
Analyst, H. V. Ellsworth

SiO_2	25.97
ThO_2	0.14
$(Ce, La, Di)_2O_3$	2.85
$Yt, Er)_2O_3$	46.47
Fe_2O_3	2.34
FeO	5.82
MnO	1.17
BeO	10.29
Al_2O_3	0.32
CaO	2.36
MgO	0.55
Na_2O, K_2O	0.09[1]
H_2O	1.23
P_2O_5	trace
U	Not detected
	99.60

[1] Weight as chlorides.

This is the first and only gadolinite so far definitely identified from a Canadian locality.

SOME STAGES IN THE DISINTEGRATION OF GLAUCONITE

Benjamin Gildersleeve, *University of Virginia.*

Introduction

Specimens of glauconitic sands upon which this paper is based were collected in the vicinity of Stafford Court House, Virginia, and at Woodstock, on the south bank of the Potomac River, 31 miles east of Fredericksburg. The horizon for all these specimens except one is the Aquia formation, or lower Eocene. One specimen from the Nanjemoy has been studied. The material to be considered is consolidated, thin sections of which have furnished excellent grains of glauconite.

This region forms the northern most exposures of the Virginia Eocene belt which is an extension of the same beds from Maryland.

The earliest studies on the Virginia Eocene were those of William B. Rogers and later by N. H. Darton, W. B. Clark and others.

Types of Sediments Carrying Glauconite

Glauconite occurs principally as amorphous, loosely granular, or massive grains disseminated in sands, sandstones, and clays. It is more rarely found in limestones and as green earth filling cavities in erruptive rocks.

Arenaceous materials, particularly sand, when mixed with glauconite are known as greensands. The term is commonly used to embrace argillaceous deposits as well, but strictly speaking, greensand is sand characterized by the presence of the mineral glauconite.

Associated Minerals

The minerals commonly associated with glauconite in order of their importance are: quartz, feldspar, hornblende, magnetite, augite, zircon, epidote, tourmaline, garnet, and other minerals in smaller amounts. Clay and fragments of continental rocks such as gneiss, mica schist, granite, and diabase may be present. If greensand is distinctly calcareous it is generally called greensand marl. Phosphate of lime frequently occurs in greensand deposits and acts as a cement in binding the smaller grains of glauconite together, thus forming nodules.

Physical Properties and Origin

Glauconite grains are usually well rounded and at times mammillated, whereas the other minerals present in greensands are, for the most part, angular. The color of glauconite grains is usually black or dark green when fresh, and brownish when altered. According to Dana the hardness is 2 in Mohs's scale of hardness, and is easily crushed. Its specific gravity varies from 2.29 to 2.35. Fine punctures sometimes occur on the surfaces of the grains, indicating the punctate nature of the foraminifera tests in which they were formed. At other times they show smooth and shiny surfaces. More generally the surfaces are dull and irregular in outline. In size the grains average 1 mm. in diameter.

In 1855 Ehrenberg first showed the relationship between greensand and foraminifera. His studies were based on material sent him by Professor J. W. Bailey, who in 1845 found large numbers of foraminifera in various Cretaceous and Tertiary marls of the United States, and called particular attention to the occurrence of casts of the shells in the Eocene at Fort Washington, Maryland. Ehrenberg attributes the formation of greensands to the filling up of the interior space of minute bodies, particularly foraminifera, with a green colored opal-like mass, which forms a cast. This peculiar natural injection is often so perfect that the large cells, and even the finer divisions, are petrified and separately exhibited. Such fine and perfect injections could not be formed by any mechanical method.

Professors Murray and Renard in their report upon the deep-sea deposits they obtained from the Challenger expedition of 1872–76, give a very satisfactory explanation of the formation and origin of glauconite which will not be reviewed here.

The mineral glauconite is essentially a hydrous silicate of aluminum, iron, and potash. Because of its green color it was assumed for a long time that all the iron was in the ferrous state, but a study made of the New Jersey greensands, following the suggestions of Professors Dana and Brush, showed that nearly four-fifths of the iron is in the ferric condition.

It is the general consensus of opinion that glauconite is a secondary chemical deposit of marine origin. Its association with foraminifera and other organisms is so intimate that its marine origin seems unquestionable. In many instances glauconite grains are distinct internal casts of these organisms, although in the Virginia

Eocene deposits foraminifera casts are less distinctly seen than in more recent deposits.

Glauconite is only formed in the presence of land-derived materials, and for this reason is restricted in area to regions in proximity to the shore where deposition is slow and the sediments have been extensively decomposed by long exposure to marine water. Large rivers flowing into the sea or strong currents carrying sediments interfere greatly with its formation and prevent continuous distribution for any great distance, and may indeed cause its formation to cease altogether.

It has been estimated that approximately 1,000,000 square miles of sea floor are now covered with glauconite deposits. The depth is usually between 100 and 200 fathoms, although it has been found at depths as great as 900 fathoms.

Greensands of the Virginia Eocene

The Eocene deposits of Maryland and Virginia consist largely of greensand marls which on weathering lose their characteristic green color and become buff colored sands, discolored and cemented in places by hydrous iron oxide. In Virginia the Eocene strata attain a thickness of 225 feet. The strike of the formations is almost due north and south, the beds having a gentle dip to the east of from 12 to 15 feet to the mile. The greensands are largely unconsolidated. Layers of indurated greensands occur along the bluffs near the mouth of Aquia Creek and a local development of silicified ledges is present in the vicinity of Stafford Court House and Brooke. Aside from these occurrences the greensands of the Virginia Eocene are not consolidated except as nodular concretions.

The Eocene sands vary from light to dark green depending on the degree of weathering and amount of water present. The more weathered sands are stained brown by iron oxides. Quartz is the most abundant mineral in addition to glauconite. Small angular grains of muscovite give a glistening appearance to much of the greensand. Irregular grains of magnetite, feldspar, and fragments of comminuted shells are also present.

Associated Fossils

The fossil faunas associated with the consolidated material are principally molluscan forms preserved as silicified and calcified, casts, molds, and imprints. The following species have been identified.

Turritella mortoni Conrad
Lunatia marylandica? Conrad
Calyptraea aperta Solander
Strepsidura subscalarina Heilprin
Tudicla?
Meretrix ovata Conrad
Panopea elongata Conrad
Phenacomya petrosa Conrad
Cucullaea gigantea Conrad
Ostrea sp.

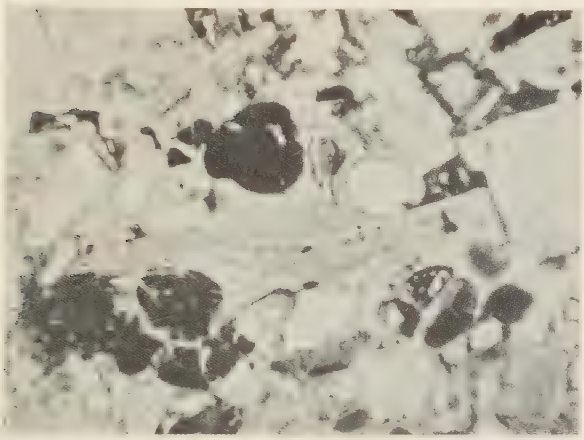


FIG. 1. Photomicrograph showing altered glauconite grains and angular quartz in a dense opaline groundmass. Some of the grains are highly fractured, while others are unbroken. X 26.

SOME OF THE STAGES OF DISINTEGRATION

As seen in thin sections glauconite occurs as scattered irregular grains and masses in an opaline groundmass which is thickly studded with angular grains of quartz. The grains always have a smooth rounded edge, even when fractured. They vary from light to dark green in color when fresh, and from light yellow to dark brown when altered. In size the grains rarely exceed 1 mm. in diameter. The shape of the glauconite grains is of no one particular type or types. In the majority of observations made two shapes were noticeable, namely, the somewhat equi-dimensional and the elongated grains, the latter being somewhat sack-shaped.

The glauconite grains appear fractured or broken in various ways; the fractures may extend through the entire grain, they may

be limited largely to the periphery, they may be observed chiefly in the interior, and in a number of instances the grains showed a sheared or shredded pattern. This fracturing is difficult to explain as due entirely to movements in the sediments and rocks as some grains were badly fractured while adjacent grains were unusually free from fractures as illustrated in figure 1.

Weathering has, in the majority of cases, accompanied this shattering process. In the elongated grains this weathering sometimes is oölitic in character, in which the dark brown to black

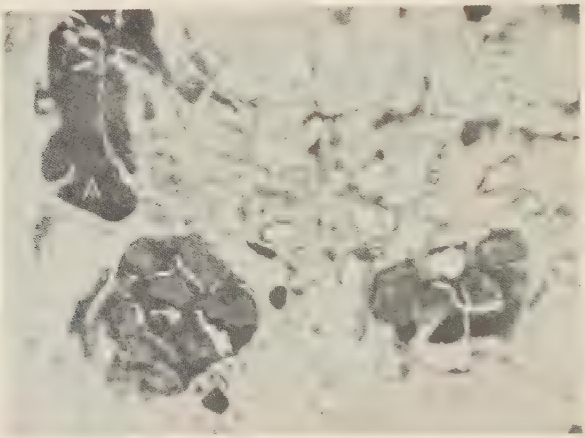


FIG. 2. Photomicrograph showing fractured glauconite grains replaced by hydrated iron oxides. The grain indicated by "A" has been completely replaced. X 26.

oölites consist of hydrated oxides of iron. In those specimens in which the fracturing involves the entire grain, as in figure 2, limonite or some other hydrated iron oxide has replaced the glauconite along the fractures, forming an opaque zone surrounding the less weathered glauconite. In some cases the entire grain has altered to limonite (Fig. 2) and it is to be noted that iron oxide may also occur throughout fragments of the grain more or less uniformly disseminated. In those cases in which the grain appears to have been sheared, the fractures are generally arcuate or almost straight; and the weathering manifests itself by alternate parallel bands of light and dark green to brown colors. In some glauconite grains irregular masses of iron oxides occur as inclusions.

Thus, the suggestion offered for the fractured condition of the grains is that it may be due, to some extent, to processes of weathering and the pressure developed by the growth of the hydrated iron oxides. It is conceded that stresses and strains brought to bear on the rocks have also been contributing factors.

CONCERNING BASALTIC GLASS

Richard E. Fuller, *University of Washington.*

Evidence of the Syngenetic Alteration of Sideromelane

In the western portion of the Columbia River Plateau, a number of basaltic flows show evidence of aqueous chilling. A variety of results have been achieved dependent on the depth of the water and the fluidity of the lava.[1] Whether it caused granulation or the formation of ellipsoidal masses, the lava, which came in contact with the water, has invariably been chilled to the transparent variety of basaltic glass known as sideromelane. This substance has been largely altered to palagonite, a hydrated mineraloid. In the past this alteration has been attributed[2] chiefly to later agencies. In a previously published petrographic description of the sideromelane and palagonite of this region it was stated, however, that field evidence "strongly indicates that the palagonitization of these tuffs was effected by the steam generated in the quenching of the extruded material."[3] Strong testimony to this statement may be observed at two localities.

On the eastern wall of the Columbia River valley at about three miles south of the mouth of Moses Coulee, a steep straight cliff exposes for nearly a mile the chilled basal phase of a very fluid flow which advanced into shallow water gradually building at its margin a breccia formed largely of granulated glass enclosing ellipsoidal masses. This heterogeneous basal phase accumulated with well-defined foreset bedding, which is here shown in an ideal cross-section. The bedding dips to the north and thereby indicates that the flow advanced from the south. Traced northward the overlying massive lava, which had flowed over its chilled base almost as if on dry land, thins out and the breccia, while still retaining its uniform thickness, ceases abruptly with an inclination parallel to the dip of the foreset bedding. Normal to this slope rises the columnar jointing of a later flow without any indication of intense chilling.

[1] R. E. Fuller, The Aqueous Chilling of Basaltic Lava on the Columbia River Plateau: *Am. Jour. Sci.*, vol. **XXI,** pp. 281–300.

[2] R. Bunsen, Beitrag zur Kenntniss des Islandischen Tuffgebirges: *Annal. Chem. u. Pharm.*, vol. **LXI,** p. 279, 1847; W. S. von Waltershausen, Ueber die submarinen Ausbrüche in der Tertiär-Formation des Val di Noto im Vergleich mit verwandten Erscheinungen am Aetna: *Gött. Stud.*, p. 400, **1845**; M. A. Peacock, The Petrology of Iceland, Preface and Part 1—The Basic Tuff: *Trans. Roy. Soc. Edinburgh*, vol. **LV,** pp. 70–71, 1926.

[3] M. A. Peacock and R. E. Fuller, Chlorophaeite, Sideromelane and Palagonite from the Columbia River Plateau: *Am. Mineralogist*, vol. **13,** p. 376, 1928.

Near the northern end of the flow, the breccia is unaltered and remains as a porous mass of broken fragments of black vitreous sideromelane, which is finely to coarsely vesicular.[4] This material is locally cemented with calcite. Palagonitization is encountered fairly sharply at the base of the exposure about a hundred yards south of the margin of the flow. As seen from a distance the line of demarcation between the yellowish breccia and the dark one cuts diagonally across the foreset bedding with a still lower dip to the north.

The coincidence of this lack of alteration with the end of the flow strongly suggests the palagonitization of the breccia to be syngenetic with the advance of the lava. Two factors are considered by the writer to be responsible for this phenomenon. With the gradual diminution of the advancing lava, the water at the contact would have been less intensely heated. At the same time, the thinning of the capping flow would have facilitated the escape of steam. Although these two factors would explain the progressive decrease in alteration towards the nose of the flow, the reason for the sharp contact between the two facies is problematical.

Additional evidence of syngenetic alteration may be observed in the valley of Douglas Creek at about half a mile from Moses Coulee. Here, massive palagonitic breccias are intermingled with micaceous sediments, which in part remain as angular blocks. The relation is attributed to the advance of very fluid basalt into a lake containing partially consolidated sediments. In this instance the quantity of water was sufficient to completely quench the flow.[5]

Although the granulated sideromelane of the massive breccia is almost completely altered to palagonite, the glass embedded in the sediments or in contact with the blocks of sandstone is perfectly fresh. The sediments are considered by the writer to have protected the fragments from the intense steam action both by coating them and by reducing their temperature. The latter factor probably is far the more important.

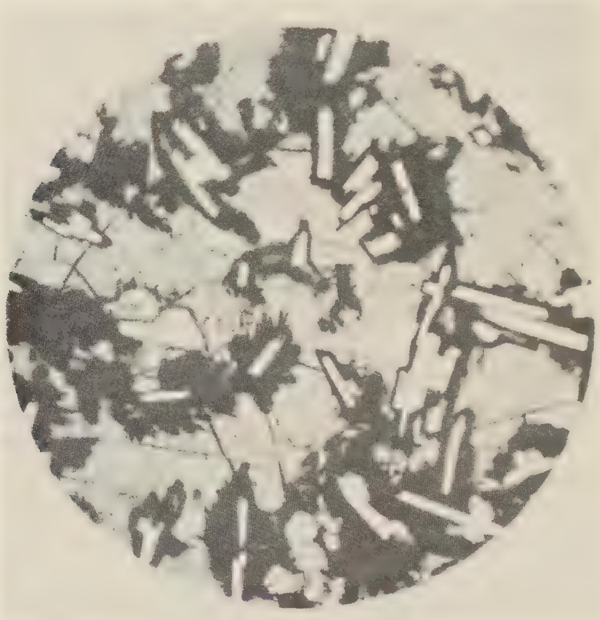
Transition from Sideromelane to Tachylyte in the Chilled Basal Facies of the Flows

The pillows are invariably coated with black vitreous sideromelane which in thin section is a pale olive-buff. At the outer margin,

[4] A petrographic description of a typical specimen of this rock has been previously described, M. A. Peacock and R. E. Fuller, *op. cit.*, p. 370.

[5] R. E. Fuller, *op. cit.*, pp. 295–298.

the glass, which exhibits a rough conchoidal fracture, is traversed by a net work of contractional cracks forming irregular polygons, the smallest of which are about 1 cm. in diameter. At a depth of about 1 to 2 cm., these joints end abruptly at an irregular crack that roughly parallels the surface. Below this the glass develops a finer system of contractional cracks, which divides it into smaller units averaging approximately .5 mm. across. With this change the fracture becomes minutely hackly although it still retains a pitch-like lustre.



Photomicrograph showing the dark brown substance forming in sideromelane around crystals of labradorite and pyroxene at about 4 cm. from the surface of a basaltic ellipsoid. Note both the characteristic feathery outline of the dark precipitate and and the local gradational relation to the enclosing glass. X 98.

The rate of cooling varies even in individual pillows depending largely on the proximity of the major joint cracks, but at a depth of about 4 cm. the rock as a rule begins to lose it hackly fracture and extreme vitreous appearance. Here a thin section shows a dark brown semi-opaque substance with a rather feathery outline forming in the glass around the microscopic crystals of feldspar and pyroxene. (See figure.) Traced inwards from the surface of these

pillows the dark masses become more opaque and increase in concentration, until the sideromelane survives only as small isolated patches and then disappears leaving the crystals of plagioclase and pyroxene in an opaque ground.

In this transitional zone, which has a depth of about 1 cm., the sideromelane may be observed to become slightly grayish in reflected light. The brown substance, which is isotropic is very variable in its degree of translucence. In part its boundary appears gradational to the sideromelane and the small joint cracks may locally be traced directly across it. More often it shows a clean cut outline with flamboyant marginal projections, which taper to a rounded or pointed end. Many of the latter are distinctly curved. These projections, which range from .003 to .015 in width, locally attain a length of 0.1 mm.

The brownish material has a higher index of refraction than the sideromelane, but the writer did not succeed in isolating it in order to determine its numerical value. Its formation, however, is definitely a transitional step in the development of an opaque ground composed of dustlike particles and thin needles of magnetite in a grayish ground. This heterogeniety is considered by the writer to be characteristic of tachylyte for it is identical in appearance to the fresh glassy margin of several dikes, when examined microscopically in reflected light.

Although both the color and petrographic relations of the brown substance suggest that it is the initial step in the formation of magnetite, it is not magnetic and must have undergone considerable molecular concentration with further crystallization. Presumably it represents globulites, cumulites and crystalites of magnetite which Harker[6] has previously described in basaltic glass. His description, however, applied to a type that would be here classed as a transitional facies, for he states that it consists of a brown or yellow glass densely charged with a separation of magnetite.

The gradational increase in the precipitation of the iron oxide emphasizes the distinction between transparent sideromelane, which has suffered ultrarapid chilling, and the more familiar opaque tachylyte, which has formed beneath an insulating layer of glass. In contrast to these types, the final mesotasis of crystalline basalt is not uncommonly formed of a fairly transparent light brown glass. The clarity of this slow cooling variety is presumably due to the previous separation of magnetite.

[6] Alfred Harker, *Petrology for Students*, Cambridge **1923**, p. 190.

PROCEEDINGS OF THE TWELFTH ANNUAL MEETING OF THE MINERALOGICAL SOCIETY OF AMERICA AT TULSA, OKLAHOMA

Frank R. Van Horn, *Secretary.*

The Mineralogical Society of America held its twelfth annual meeting on December 29 and 30, 1931, in conjunction with the Geological Society of America, at the Mayo Hotel, Tulsa, Oklahoma, as guests of the Tulsa Geological Society, and the American Association of Petroleum Geologists. On Tuesday, December 29, at 2:00 P.M., President A. H. Phillips called the regular annual meeting to order. On motion of the Secretary, the reading of the minutes of the last annual meeting was dispensed with, in view of the fact that they have been printed on pages 107–119 of volume **16** (Number 3) of *The American Mineralogist.*

ELECTION OF OFFICERS AND FELLOWS FOR 1932

The Secretary announced that 176 ballots had unanimously been cast for the officers as nominated by the Council. For fellows, there was a unanimous vote of 69 ballots in the affirmative. All officers and fellows were declared elected.

The officers elected for 1932 are the following:

President: Alexander N. Winchell, University of Wisconsin, Madison, Wisconsin.

Vice-President: Joseph L. Gillson, E. I. Dupont de Nemours & Co., Wilmington Delaware.

Secretary: Frank R. Van Horn, Case School of Applied Science, Cleveland, Ohio.

Treasurer: Waldemar T. Schaller, U. S. Geological Survey, Washington, D. C.

Editor: Walter F. Hunt, University of Michigan, Ann Arbor, Michigan.

Councilor 1932–1935: William J. McCaughey, Ohio State University, Columbus, Ohio.

The fellows elected follow:

Dr. Olaf Anderson, Research Laboratory, United States Steel Corporation, Kearney, New Jersey.

Dr. Richard C. Emmons, Assistant Professor of Geology, University of Wisconsin, Madison, Wisconsin.

Dr. James E. Hawley, Professor of Mineralogy, Queens University, Kingston, Ontario, Canada.

REPORT OF THE SECRETARY FOR 1931

To the Council and Members of the Mineralogical Society of America:

The Secretary herewith begs to report that the roll of the Society now consists of 115 fellows and 310 members in good standing, which is a gain of 37 over last year. One honorary life fellow, Professor Friedrich J. Becke; one fellow, Arthur S. Eakle and four members, A. C. Burrage, W. E. Biglowe, T. C. Crosby and T. A. Smith, have died during the year. In addition to the 425 fellows and members, there are 233 subscribers to the Journal, an increase of 19 over the previous year. Actually, during the past year, 3 fellows, 65 members and 29 subscribers, a total of 97, were added to the list, but deaths, resignations, with non-payment of dues and subscriptions, have reduced the mailing list by 2 fellows, 26 members and 8 subscribers, a total of 36, making a net gain in all classes for the year of 61. A total of 658 paid copies of *The*

American Mineralogist are mailed monthly, or a gain of 56 over last year. It is felt that the Society has increased quite satisfactorily over the previous year.

Respectfully submitted,

FRANK R. VAN HORN, *Secretary*

On motion, the report of the Secretary was accepted and ordered filed.

REPORT OF THE TREASURER FOR 1931

To the Council of the Mineralogical Society of America: Your Treasurer submits herewith his annual report for the year beginning December 1, 1930, and ending November 30, 1931.

RECEIPTS

Cash on hand December 1, 1930	$1,097.41	
Dues and subscriptions	2,044.17	
Advertisements	495.71	
Sale of back numbers	197.70	
Interest on endowment and bank interest	2,566.48	
Miscellaneous	28.34	
		$6,429.81

DISBURSEMENTS

Printing and distribution of the Journal (12 issues)	$3,795.62	
Printing and distribution of separates	283.98	
To the Editor, Secretary, and Treasurer	720.00	
Postage and stationery	60.56	
Filing case and cards for Treasurer	115.61	
Reprinting Volume 6	204.13	
Refunds on dues	16.00	
Safety deposit box	7.50	
Bank exchange on foreign checks	1.69	
	5,205.09	
Cash balance November 30, 1931	1,224.72	
		$6,429.81

The endowment funds of the Society as of November 30, 1931, are the same as a year ago, and consist of:

45 $1,000 bonds of the City and County of Honolulu, Water Works, 5%	45,000.00
4 Liberty bonds, $100 each, 4th, $4\frac{1}{4}$%	400.00
4 $100 bonds, Great Northern R.R., $5\frac{1}{4}$%	400.00
2 $1000 bonds, Trenton Mort. and Title Guar. Co., $5\frac{1}{2}$, due 1937	2,000.00
2 $1,000 bonds, Trenton Mort. and Title Guar. Co., $5\frac{1}{2}$%, due 1938	2,000.00
1 $1,000 bond, Denver Gas and Electric Light Co	1,000.00
	$50,800.00

Respectfully submitted,

W. T. SCHALLER, *Treasurer*

Early in December, at the request of the treasurer, President Phillips appointed an auditing committee consisting of Vice-President, W. F. Foshag, and two non-members of the Council, Frank L. Hess and E. P. Henderson, all of Washington, D.C., who reported as follows:

Washington, D.C., December 15, 1931

The auditing committee of the Mineralogical Society of America has examined the accounts of the treasurer and found them correct and in good order.

The bonds, as listed, are in the safe deposit box with all future coupons attached.

Frank L. Hess
E. P. Henderson
W. F. Foshag

REPORT OF THE EDITOR FOR 1931

To the Council, Fellows and Members of The Mineralogical Society of America: The present year concludes the sixteenth volume of *The American Mineralogist.* A cursory examination of the Journal during this period will reveal a considerable variation in size from year to year. On only three occasions, however, have volumes been issued that have totaled 600 pages. This goal was reached first in 1928, also in 1930, and again this present year. On the two previous occasions special issues were mainly responsible for these large volumes, while in the current volume the same result has been achieved through twelve regular numbers of fairly uniform size averaging approximately fifty pages each.

You will find in examining the list of fifty-one leading articles, which constitutes nearly 88 per cent of the total space of the Journal, practically every phase of mineralogy and crystallography represented. Thirteen articles have been classified as belonging to the division of descriptive mineralogy; eleven to chemical mineralogy; seven have stressed optical data; nine have been assigned to structural and two to geometrical crystallography; while addresses, memorials and articles of a miscellaneous character are represented by nine contributions. Included in the list are the detailed descriptions of four new minerals—schairerite, clarkeite, fervanite and krausite.

To those who might possibly question the propriety of publishing in the Journal certain manuscripts that were accepted this year, on the grounds that the organic compounds described were not minerals, I should like to call attention to Article 5 of the By-laws that provides that "The Society shall publish a Journal devoted to the advancement of mineralogy, crystallography and allied sciences." It is believed that all papers that have appeared this year came easily within the broad limits outlined by that general provision.

In a number of respects the current volume was quite unique. Of the fifty-one main articles, ten represented contributions from foreign countries—three from Germany, two from Sweden, two from England, and three from Canada. This is the largest number of manuscripts it has been our good fortune to receive from outside of the States for any one year period. During the past year fifty-six individuals representing thirty different universities, research bureaus, and technical laboratories have contributed one or more leading articles. These figures indicate in some degree the far-reaching service rendered by the Society's publication and the general interest shown in the Journal both here and abroad.

Aside from the longer contributions referred to, nine shorter articles have appeared under the division of Notes and News. Also, as in the past, considerable space was accorded to brief items of interest, book reviews, new mineral names and the proceedings of five Mineralogical Societies. In Volume 16 approximately 73 pages have been devoted to the items just enumerated. The volume has also been very profusely illustrated as is shown by the 198 illustrations distributed throughout the text.

At this point a suggestion might well be offered. The number of illustrations is mounting rapidly. An increase of forty-six was noted over that of a year ago. Due to the rather high cost of reproductions, it is urged that contributors restrict the number of cuts to those absolutely necessary. Any superfluous illustrations are an added burden upon the Society. Since the Council has been exceedingly liberal in granting 100 free reprints to authors, it might be suggested that this generous action should warrant somewhat greater economy in the number of cuts submitted, or at least a willingness on the part of the author to help defray the cost whenever the number of illustrations seems excessive.

A year ago the Council authorized the reprinting of Volume 6 (1921) as the surplus stock of that volume had become almost completely exhausted through the sale of back numbers. Two hundred additional copies have now been reprinted by a special photographic method at a cost of approximately $200, so that we are now in a position to fill all orders that we are likely to receive for some time to come.

In the May issue of the *Mineralogist* a request was made for contributions to be used during the summer months. The response that followed was most gratifying and was reflected in the increased size of the last four issues of the Journal. It is hoped that this custom of completing all manuscripts before entering upon field work or other summer duties will be continued, for only by so doing can the size and character of the Journal be maintained during this otherwise lean period.

For the coming year an effort will be made to again issue a 600-page volume. This goal, in the light of past accomplishments, is not unreasonable and is one that our present financial income is able to underwrite.

Finally, no doubt many of our readers will be interested to learn that the *Mineralogist* is attempting to compile an up-to-date list of the more important mineral collections, both public and private, in the United States and Canada. Mr. Samuel G. Gordon of Philadelphia and Mr. Hugh S. Spence of Ottawa have been very active in this undertaking and considerable information has already been accumulated. It is thought that the work can be completed during the coming year and the data published in the Journal in the form of a regional directory.

The concluding table of contents summarizes the distribution of subject matter in Volume 16.

DISTRIBUTION OF SUBJECT MATTER IN VOLUME 16

Subjects		*Articles*	*Pages*	*Per cent of Total*
Leading articles				
Descriptive mineralogy	13			
Chemical mineralogy	11			
Optical crystallography	7			
Structural crystallography	9			
Geometrical crystallography	2			
Addresses, memorials, etc.	9			
		51	521½	87.8

Subjects	*Articles*	*Pages*	*Per cent of Total*
Proceedings of societies	21	$40\frac{1}{2}$	12.2
Notes and news	23	$17\frac{1}{2}$	
Abstracted accounts of new mineral names	10	6	
Book reviews	15	$8\frac{1}{2}$	
Total of text	120	594	100.0
Illustrations	198		
Covers, advertisements, index		126	
Total		720	

Respectfully submitted,

WALTER F. HUNT, *Editor*

REPORT OF THE NEW COMMITTEE ON NOMENCLATURE AND CLASSIFICATION OF MINERALS

No progress has been made since the report presented at the last meeting of the Society, December 29, 1930. Owing to unexpected conditions, the Chairman was not able to submit the report to the members of the Society in 1931, but will do so early in 1932, for acceptance or rejection by the Society in December, 1932.

The committee asks that it be continued.

W. T. SCHALLER, *Chairman*
W. F. FOSHAG
E. S. LARSEN
J. F. SCHAIRER
T. L. WALKER
A. N. WINCHELL

It was moved, seconded and carried that the committee be continued.

REPORT OF THE REPRESENTATIVE ON THE NATIONAL RESEARCH COUNCIL

Several lines of research that are being pursued under the auspices of the Division of Geology and Geography of the National Research Council will be of interest to mineralogists.

An important report issued during the year is Bulletin 80, on "The age of the earth." This is an exhaustive investigation of methods and criteria for determination of geologic age. The parts discussing the studies of radioactive minerals will interest most mineralogists.

The committee on "Batholiths and mechanics of igneous intrusion" has prepared an exhaustive bibliography that will be useful to mineralogists as well as petrologists.

The subcommittee on "Criteria of paragenesis of ore minerals" has issued a final report, published in the September-October issue of *Economic Geology*. The criteria here discussed are primarily for the opaque ore minerals, but will be useful in all studies of mineral genesis and mineral sequence.

As usual, the report of the committee on "Sedimentation" contains abundant material of great value. All the different subjects reported upon can not be enumerated here, but the reports of progress, the reviews of papers, and the bibliographies contain material of the utmost usefulness.

The committee on "Potash-soda feldspars" reports that artificial members of the plagioclase series are being made which will permit much more accurate plotting of the optical properties.

The committee on the "Investigation of the clay minerals" reports a continuation of the studies of these minerals, and the publication during the year of a detailed report on "The kaolin minerals," by the U.S. Geological Survey.

CLARENCE S. ROSS

REPORT OF COMMITTEE ON COOPERATION WITH THE SECRETARY OF THE XVI INTERNATIONAL GEOLOGICAL CONGRESS, ALONG THE LINES OF MINERALOGY AND PETROLOGY

The committee has cooperated satisfactorily with the committee on excursions of the Sixteenth International Geological Congress. The excursions as now outlined embrace a satisfactory amount of mineralogical and petrological interest.

Since the Congress has been postponed until 1933, the committee suggests that it be continued so as to be available for any further cooperation that may be deemed desirable.

W. F. FOSHAG, *Chairman*
W. T. SCHALLER
J. F. SCHAIRER

It was moved, seconded and carried that the committee be continued.

NEW BUSINESS

It was moved by T. L. Walker and seconded by A. F. Rogers that the Society extend New Year's greetings to our Honorary Life Fellow, Professor Victor Goldschmidt of Heidelberg, Germany. The motion was carried.

At a meeting of the Council this morning it was voted that the Society have an official luncheon during the meetings, and the incoming president, Dr. A. N. Winchell was appointed to make arrangements. Dr. Winchell announced that such a luncheon would take place at 1:00 P.M., Wednesday, December 30, in the English room of the Mayo Hotel.

MEMORIAL BIOGRAPHIES

In view of the fact that none of the authors of the memorial biographies were present, and also that the articles will be printed in full in the Journal, it was moved, seconded and carried that they be read by title. They were as follows:

Memorial of Friedrich J. Becke (died June 18, 1931), by E. H. Kraus.

Memorial of Arthur S. Eakle (died July 5, 1931), by W. T. Schaller.

PRESENTATION OF PAPERS

At 2:45 P.M., there being no further business, the Society proceeded to the reading of scientific papers. The papers presented with short abstracts follow:

AUSTIN F. ROGERS: *The Linear Projection in Geometrical Crystallography.* It seems advisable to use some generalized form of projection in elementary crystallography. The stereographic and gnomonic projection, excellent for advanced work, are hardly suitable for elementary classes, but in the linear projection of Quenstedt

we have a simple form of projection which is both convenient and useful. It probably furnishes the best method of bringing out the relations between faces and zones and may also be used for constructing clinographic drawings.

CLARENCE S. ROSS and E. P. HENDERSON, (read in abstract by the Secretary): *Variations in Optical Properties and Composition in the Anthophyllite Series.* A number of analyses of anthophyllites and ferroanthophyllites have been made and the optical properties determined. This permits a more accurate plotting of the variations of optical properties with variations in chemical composition. Some of the curves heretofore given have been based on the properties of an artificial magnesium end member. Such artificial material is now known not to be anthophyllite. Naturally occurring material has been used in all determinations in the present study.

ALEXANDER N. WINCHELL: *Ferrotremolite, Oxyhornblende, and Tourmaline.* The new names, ferrotremolite and oxyhornblende are suggested and explained. Following the work of Kunitz, the relations between chemical composition and optical properties in various kinds of tourmaline are shown by means of diagrams.

CHARLES PALACHE and W. F. FOSHAG, (read by Charles Palache): *The Chemical Nature of Joaquinite.* A chemical analysis of this incompletely described mineral shows it to be a titanosilicate of barium and sodium. $Na_6(Ba, Fe)_6Ti_{10}Si_{16}O_{61}$. Its physical properties are described and its paragenesis and relations to other minerals of similar composition are discussed. It is orthorhombic, and has a density of 3.89. Its refractive indices are: $\alpha = 1.748$, $\beta = 1.767$, $\gamma = 1.823$.

W. T. SCHALLER (read by F. R. Van Horn): *Bavenite, a Beryllium Mineral, Pseudomorphous after Beryl, from California.* Bavenite from Mesa Grande, California, forms a pseudomorph after beryl. Bavenite contains about 3 per cent BeO and was identified in the mineral from Italy, as well as in the pseudomorphous mineral from California. The crystals from the two localities are almost identical in habit. The formula of bavenite is $9SiO_2$. Al_2O_3. BeO. 4CaO. H_2O. Spectrographic analyses show the presence of beryllium and the identity of Italian and Californian minerals.

CHARLES PALACHE AND F. A. GONYER, (read by Charles Palache): *On Babingtonite.* Babingtonite from four new localities, all in Massachusetts, is described. Four new chemical analyses show an extraordinarily constant composition and lead to the formula $Ca_2Fe''Fe'''Si_{14}(OH)$. The form, optical and other physical characters are shown to be essentially identical in all occurrences. Reasons are given for regarding babingtonite as not belonging either to the pyroxene group, the "triclinic pyroxene" group, or the feldspar group of minerals, in all of which it has been at one time or another classified. Rather it is to be considered as standing quite alone and without near relatives. Its paragenesis is discussed and it is shown to be characteristically a low temperature hydrothermal mineral.

HARRY BERMAN (read by Charles Palache): *Fibrous Brucite from Quebec.* Fibrous brucite or nemalite was identified in veins in the chrysotile asbestos deposits of Quebec. The fibers probably replaced earlier chrysotile. Optical study shows each lath-like fiber to be a hexagonal plate enormously distorted in the direction of one of the horizontal axes. The analysis shows it to be a brucite with a small amount of iron.

AUSTIN F. ROGERS: *Euhedral Gold Crystals from Mariposa County, California.* The North Duncan gold mine near Hornitos, Mariposa County, California, has furnished some noteworthy specimens of crystallized gold implanted on quartz. The gold occurs for the most part as cubo-octahedra modified by the trapezohedron (311). The crystals are rather small, but are very sharp and clear cut.

G. M. HALL: *Flattened Minerals in Muscovite at Spruce Pine, North Carolina.* The flattened minerals were collected in April 1931, from the Chestnut Flat Feldspar Mine near Spruce Pine, North Carolina. The flattened minerals are garnet, zoisite and magnetite, and they occur in books of mica in a pegmatite dike which consists essentially of orthoclase. The occurrence of zoisite in muscovite is uncommon, but the occurrence of the other two minerals is not. The magnetite contains unusual partings. Some of the crystals are so thin that they appear to be in minute openings between the cleavage planes of the mica, but other crystals are thicker and cleavage flakes of mica contain holes made by garnet and zoisite. The flattened minerals were apparently formed during the same period in which the mica crystallized.

KENNETH K. LANDES: *The Baringer Hill, Texas, Pegmatite.* The Baringer Hill pegmatite lies near the center of the Llano or Central Mineral Region about 100 miles northwest of Austin, Texas. The pegmatite is intruded into granite which in turn is intruded into pre-Cambrian metamorphic rocks. Baringer Hill is famous for its yield of rare earth minerals, especially gadolinite, cyrtolite, allanite, and fergusonite. But these and similar minerals constitute much less than one per cent of the total mass of the pegmatite. The most abundant minerals are quartz, microcline, and albite. All of the rare earth minerals and some of the other minerals were deposited by hydrothermal solutions, replacing older minerals.

F. R. VAN HORN: *The Spodumene Bearing Pegmatite from the Etta and Hugo Mines, Black Hills, South Dakota.* The writer visited these properties in July, 1931, and lantern slides are shown of the various open cuts which are about two miles south of Keystone, and twenty-two miles southwest of Rapid City. The Etta Mine has been known since 1880 as a mica mine, tin mine, and spodumene mine. It has long been famous for the size of the spodumene crystals. Schaller in 1904 mentioned one 47 feet long which should weigh 90 tons. No large crystals were seen in the open cut, and present mining is under ground. About 50 minerals have been found at the Etta.

The Hugo Mine, formerly called the Christianson, is working on two open cuts, and the same minerals are found as at the Etta, but amblygonite, which is a more desirable lithium mineral than spodumene, is found in greater amounts. Masses of 300–400 pounds are numerous. Minerals hand cobbed and saved for shipping were amblygonite, spodumene, yellow muscovite, and feldspar (microcline in my specimens). Columbite is found in masses up to 100 pounds.

W. A. TARR: *A Barite Vein in the Granite of Southeast Missouri.* A barite vein that cuts the pre-Cambrian granite of southeastern Missouri is described. The vein is narrow but well defined. The minerals are barite, pyrite and fluorite. The finding of this vein in granite settles an important question as to the origin of the barite in the nearby barite district. The origin and its significance was discussed.

After a discussion of this paper by O. R. Grawe, and a reply by Dr. Tarr, the Society voted to adjourn at 5:00 P.M., and to meet on Wednesday at 10:00 A.M., so that members might attend the general session of the Geological Soceity at 9:30 A.M.

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On Wednesday, December 30, at 10:05 A.M., President Phillips called the second session of the Society to order, and the reading of papers proceeded according to program.

FANNY CARTER EDSON: *Heavy Minerals as a Guide in Stratigraphic Studies.* Heavy minerals are one of the accepted means of stratigraphic correlation and they have served as an invaluable stratigraphic guide in Mid-Continent correlations. Proper well sampling and laboratory methods of analysis to correlate both surface and underground formations are explained. Important geological data that may be deduced from these analyses are suggested. The results obtained from the application of these methods to the study of sandstones of Ordovician age in the Mid-Continent oil field are discussed. These minerals are chiefly tourmaline, zircon, rutile and garnet.

EDWIN T. HODGE (read in abstract by the Secretary): *Petrographic Succession of Tertiary Igneous Rocks in Oregon.* Igneous activity began in Oregon in the early Paleozoic and has continued uninterrupted down to the present time. During the Tertiary, vulcanism has been the dominant process, sedimentary rocks making up less than 5 per cent of the formations. Tertiary vulcanism has been both intense and extensive. It may be said that Oregon is outstanding in the length, intensity, and extensiveness of its volcanic activity. Tertiary vulcanism has alternated between periods of widespread explosive and quiescent stages. These go in pairs. Between each pair there has been a period of deformation and erosion. The intensity of deformation and the length of the period of erosion has become decreasingly less so that in the Pleistocene vulcanism has proceeded on an unparalleled scale, and the Recent period gives promise of exceeding that of the Pleistocene. Publications on Oregon petrography are scattered and few. The paper presents, in a preliminary way, results of geologic mapping of the last ten years covering about one-tenth of the state, and representing samplings of many formations. It shows the pendulations back and forth between various magmatic poles. A quantitative statement of the various rock types will be presented.

EDWIN B. ECKEL (introduced by W. S. Burbank), read by W. S. Burbank: *Garnet as an Amygdule Mineral.* Near Ouray, Colorado, the intrusion of a gabbrodiorite stock has caused the development of garnet in the amygdules of andesite flows by contact metamorphism.

The original amygdule fillings consisted of chlorite, quartz, and calcite, with minor amounts of barite, chalcedony, and opal. Close to the intrusive body andradite garnet appears in some of the amygdules as rounded grains embedded in quartz and calcite, or as small trapezohedrons projecting into the openings. It is never found within the andesite, nor in non-amygdaloidal vesicles, such as are characteristic of some of the flows. It is believed that the garnet formed only as a replacement of calcite and other original minerals of the amygdules.

Some of the garnet was later replaced by epidote, which also replaced the original minerals of the andesite. The formation of the epidote was followed by a further generation of quartz.

The few known occurrences of garnet as an amygdule mineral are compared to that near Ouray and points of difference and similarity discussed.

Evans B. Mayo (introduced by H. Ries), read by H. Ries: *Two New Occurrences of Piedmontite in California.* This rare mineral, probably first known to Cronstedt, who mentioned it as early as 1758, has since been found at several places in Europe, Egypt, India, Japan, and the United States. In this country it has been reported from at least five localities, two of which are in California.

A third Calfornian locality, in northeastern Madera County, near the summit of the Sierra Nevada, is here described, and the results of a study of two quite different occurrences of the mineral, namely, as a replacement of biotite in a metadacite, and as minute, acicular crystals in piedmontite-sericite schist, are given.

Inspection of a list of the known occurrences of piedmontite shows that the mineral is formed in quite a variety of geologic situations, apparently under conditions of thermal, or dynamo-thermal metamorphism.

Austin F. Rogers: *Sanbornite, a New Bariumdisilicate Mineral from Mariposa County, California.* Sanbornite is a triclinic mineral with perfect cleavage parallel to (001) and polysynthetic twinning parallel to (010). The indices of refraction are: $n_\alpha = 1.597$, $n_\beta = 1.616$, $n_\gamma = 1.624$, (all $\pm .001$). It is optically negative with $2V = 66°$ (calculated from the indices). The optical orientation is Y nearly normal to (001) and the axial plane nearly normal to (010). The chemical formula is $BaSi_2O_5$. A probable structure with $Ba_2Si_4O_{10}$ as the unit is given. It occurs in what is probably a contact metamorphic deposit (exact locality unknown) associated with quartz, diopside, tourmaline, pyrrhotite, gillespite, celsian (first reported occurrence in the U. S.), and several unknown minerals.

Charles Palache: *Zunyite from Guatemala.* Zunyite and specular hematite were found in graves in the ruins of Uaxactun, Guatemala. Zunyite was in crystals and the analysis showed the composition expressed by the formula $Al_8Si_3O_{12}(OH.\text{-}F.\ Cl)_{12}$. These minerals are shown to have probably been brought from volcanoes far to the south.

* * * * * *

The last paper was finished at 11:13 A.M., after which Dr. W. A. Tarr moved that the thanks of the Society be extended to the Tulsa Geological Society, to the American Association of Petroleum Geologists, and to the local committee for their kindness and hospitality. This was seconded by Dr. A. F. Rogers and carried. The Society then adjourned until 12:00 o'clock when it met in joint session with the Geological Society of America to listen to the presidential address of our retiring president, Dr. A. H. Phillips, on "Isomorphous Substitution of Elements in Minerals."

During the sessions of the Society, a total of nineteen scientific papers were presented, two being given in abstract. Thirty nine fellows, members and guests were present at the various meetings.

The following registered at the Tulsa meetings:

V. T. Allen	O. R. Grawe	F. H. Pough
W. S. Bayley	G. M. Hall	H. Ries
J. D. Barksdale	D. F. Hewett	A. F. Rogers
L. W. Barrett	C. W. Honess	E. Sampson
M. Bear	W. F. Hunt	E. L. Spain, Jr.
W. S. Burbank	J. H. Johnson	L. W. Staples
F. A. Burt	K. K. Landes	W. A. Tarr
L. Cahn	R. E. Landon	F. R. Van Horn
N. E. Chute	A. C. Lane	T. L. Walker
W. H. Courtier	E. B. Mathews	S. Weidman
F. C. Edson	W. J. Miller	T. W. Wilson
R. C. Emmons	C. Palache	A. N. Winchell
A. C. Giles	A. H. Phillips	R. J. Wisner

LUNCHEON MEETING

In accordance with a vote of the Council, a luncheon meeting was held on Wednesday, December 30, 1931, at 1 P.M. in the English Room of the Mayo Hotel. The meeting was presided over by Dr. A. N. Winchell, incoming president, and in order to get better acquainted with each other, he asked each one present to rise, give his name, present position, and hobby. The meeting was enjoyed by all and it was the general opinion that a similar meeting should be held each year.

EXCURSION

Through the courtesy of Mr. George C. Branner, State Geologist of Arkansas, a field trip on New Year's Day was enjoyed by certain members of the Mineralogical Society and the Society of Economic Geologists. A special sleeper left Tulsa at 11:20 P.M., December 31, and arrived at Little Rock at 8:10 A.M., January 1. After breakfast in the Missouri Pacific station, seven autos carried the party to Magnet Cove, Hot Springs, the new cinnabar deposits near Amity, and finally to the peridotite diamond bearing pipe near Murfreesboro. Returning, the party arrived at Little Rock about 11:00 P.M., having traveled 275 miles during the day. On Saturday, January 2, Mr. Branner took a smaller party to visit the nephelite syenite stock at Fourche Mountain, and the bauxite deposits of the Republic Mining and Manufacturing Company, a subsidiary of the Aluminum Company of America, at Bauxite. Those participating are greatly indebted to Mr. Branner and his friends for their kindness. Members of the Society on the excursion were: W. S. Bayley, N. E. Chute, W. F. Hunt, P. F. Kerr, K. K. Landes, C. Palache, H. Ries, E. Sampson, and F. R. Van Horn.

LIST OF FORMER OFFICERS AND MEETINGS, WITH DATES

By recommendation of the Council, a complete list of past officers is printed in the proceedings of the annual meeting of the Society.

HONORARY PRESIDENT for Life........................Edward S. Dana, 1925

PRESIDENTS	VICE-PRESIDENTS
1920 Edward H. Kraus	1920 Thomas L. Walker
1921 Charles Palache	1921 Waldemar T. Schaller
1922 Thomas L. Walker	1922 Frederick A. Canfield

1923 Edgar T. Wherry
1924 Henry S. Washington
1925 Arthur S. Eakle
1926 Waldemar T. Schaller
1927 Austin F. Rogers
1928 Esper S. Larsen
1929 Arthur L. Parsons
1930 Herbert E. Merwin
1931 Alexander H. Phillips

1923 George F. Kunz
1924 Washington A. Roebling
1925 Herbert P. Whitlock
1926 George Vaux, Jr.
1927 George L. English
1928 Lazard Cahn
1929 Edward Wigglesworth
1930 John E. Wolff
1931 William F. Foshag

Secretaries

1920–1922 Herbert P. Whitlock
1923——— Frank R. Van Horn

Treasurers

1920–1923 Albert B. Peck
1924–1929 Alexander H. Phillips
1929–1930 Albert B. Peck
1931——— Waldemar T. Schaller

Editors

1920–1921 Edgar T. Wherry
1922——— Walter F. Hunt

Councilors

1920 Arthur S. Eakle, Frank R. Van Horn, Fred E. Wright, Alexander H. Phillips
1921 Frank R. Van Horn, Fred E. Wright, Alexander H. Phillips, Austin F. Rogers
1922 Fred E. Wright, Alexander H. Phillips, Austin F. Rogers, Thomas L. Watson
1923 Alexander H. Phillips, Austin F. Rogers, Thomas L. Watson, Esper S. Larsen
1924 Austin F. Rogers, Thomas L. Watson, Esper S. Larsen, Arthur L. Parsons
1925 Thomas L. Watson, Esper S. Larsen, Arthur L. Parsons, William F. Foshag
1926 Esper S. Larsen, Arthur L. Parsons, William F. Foshag, William A. Tarr
1927 Arthur L. Parsons, William F. Foshag, William A. Tarr, Alexander N. Winchell
1928 William F. Foshag, William A. Tarr, Alexander N. Winchell, Ellis Thomson
1929 William A. Tarr, Alexander N. Winchell, Ellis Thomson, Clarence S. Ross
1930 Alexander N. Winchell, Ellis Thomson, Clarence S. Ross, Paul F. Kerr
1931 Ellis Thomson, Clarence S. Ross, Paul F. Kerr, William S. Bayley

Annual Meeting Places

1920 Chicago, Illinois
1921 Amherst, Massachusetts
1922 Ann Arbor, Michigan
1923 Washington, D.C.
1924 Ithaca, New York
1925 New Haven, Connecticut
1926 Madison, Wisconsin
1927 Cleveland, Ohio
1928 New York, New York
1929 Washington, D.C.
1930 Toronto, Canada
1931 Tulsa, Oklahoma

NOTES AND NEWS

MICRO-CRYSTALS OF BARITE FROM BARSTOW, CALIFORNIA

ARTHUR D. HOWARD, *New York University*

Recently the writer had occasion to make a lithologic study of several rock specimens from a well known vertebrate fossil locality in the Miocene-Pliocene deposits near Barstow, California. One specimen, a fairly well indurated clay, is traversed by numerous tiny slip-faults with displacements of fractions of an inch. Barite occurs along the fault surfaces. It was separated with the heavy minerals of the sediment by gravity separation. A large heavy mineral residual was obtained consisting of about 95% barite. The greater proportion of the barite occurs as sharply defined, transparent, micro-crystals. The crystals average about 0.1 mm. in length. A few

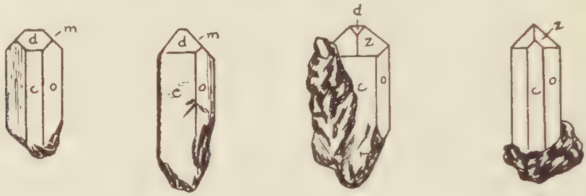

Fig. 1

are doubly terminated, although ordinarily only one end of the crystal is developed. The mineral was identified optically and checked by qualitative chemical tests. The indices of refraction agree within experimental limits with the figures given by Larsen for barite. The mineral is biaxial positive with 2V about 38°. The dispersion is weak ($\rho < v$). A comparison of the crystals sketched in fig. 1 with similar ones figured in Dana indicates that the forms present are: (001), (110), (011), (102), and (111). The crystals are authigenous and seem to have been precipitated along the fault sufaces by percolating water. The occurrence of such perfect, minute crystals in abundance in a sediment is of interest.

PRELIMINARY NOTE ON ASHTONITE

EUGENE POITEVIN,[1] *Ottawa, Canada*

The writer takes this opportunity to announce discovery of a new mineral related to the ptilolite group, to which he has given the name, ashtonite, in honour of the Honourable Wesley Ashton Gordon, Minister of Mines for Canada.

Small radiating masses of the new mineral were found in basalt five miles from Penticton, British Columbia. The mineral varies from colourless to white, lilac or brick red. It presents no crystal forms, but shows cleavage angles of 83° and 90°. It is biaxial with a large axial angle and optically positive, $\alpha = 1.481$, $\beta = 1.482$ and $\gamma = 1.486$, ± 0.001.

[1] Published with the permission of the Director, Geological Survey, Department of Mines, Ottawa, Canada.

A chemical analysis of the mineral yielded, SiO_2 63.30, Al_2O_3 11.74, Fe_2O_3 0.50, CaO 9.54, MgO 0.39, Na_2O 3.28, K_2O 0.42, BaO 0.21, H_2O 10.42; Total 99.80. This analysis yields the simple formula $9SiO_2 \cdot Al_2O_3 \cdot 2RO \cdot 5H_2O$, which differs from that of the ptilolite group by having 2RO instead of 1RO.

A fuller account of the mineral will appear in a forthcoming Museum Bulletin of the National Museum of Canada.

Watson's Microscope Record (London: 24, September 1931, page 22) carries a note on the Double Refraction of Cellophane. Sheets of this substance behave like a single crystal. They are uniform in optical character, show the same polarization color over a sheet, and definite orientation of the principal optic axes. Pieces can therefore be used in much the same way as mica and selenite plates. Cellophane has the same composition as artificial viscose silk.

The National Research Council has announced a new Committee on Accessory Minerals of Crystalline Rocks to study the nature of such minerals, their variation in time and space in igneous bodies and metamorphosed masses and their distribution in sediments. Such studies in the past have shown that some igneous masses have rather characteristic accessory minerals which may be useful in some cases in determining the relationships between isolated outcrops, but very little is known regarding the differences in different parts of a single intrusion or in successive intrusions from a single magmatic source. The committee will attempt to correlate work now in progress and stimulate further study along these lines. At present the committee consists of E. S. Larsen of Harvard, J. C. Reed of the U. S. Geological Survey, J. E. Stark of Northwesten, A. C. Tester of Iowa, A. N. Winchell of Wisconsin (chairman), and J. F. Wright of the Canadian Geological Survey.

PROCEEDINGS OF SOCIETIES

PHILADELPHIA MINERALOGICAL SOCIETY

Academy of Natural Sciences of Philadelphia, November 5, 1931

A stated meeting of the Philadelphia Mineralogical Society was held on the above date with the president, Dr. Cajori, in the chair. Forty-two members and twenty-eight visitors were present.

Mr. William T. Clay spoke on "Some Mining Camps of Colorado," descriptive of a trip taken during the summer, and visits made to various mines in company with Dr. Florian Cajori, and Mr. Lazard Cahn. Geologic details were presented, introductory to an account of the present state of activity at the various mines. Many mineral specimens and ores were exhibited.

Mr. Knabe exhibited a garnet, measuring three inches across, from the Mermaid quarry at Mt. Airy. Mr. Hoadley reported little success on a visit to the quarries near Portland, Conn., all but Strickland's quarry now being idle.

Mr. Edmund Cienkowski presented a brief report on a trip with Mr. Bernheimer to localities in England, France, Germany, and Switzerland. Fine specimens were exhibited from Cornwall, Cumberland, and Durham.

W. H. Flack, *Secretary*

Academy of Natural Sciences of Philadelphia, December 3, 1931

A stated meeting of the Philadelphia Mineralogical Society was held on December 3, with Dr. Cajori presiding. Forty-members and twenty-six visitors were present.

The resignation of Mr. Louis Bregy was read. Upon favorable recommendation of the executive council, the following were elected junior members: Louis Moyd, William H. Yost, 3rd, and Charles M. Jackson.

Dr. Edward S. Sampson of Princeton University addressed the society on "Minerals and Magmas." It is surprising how some of the rarer minerals form at all, when the amount of concentration necessary is considered in comparison with the distribution of the elements in igneous rocks. When magmas cool to form igneous rocks, the various constituents of the magma separate as minerals in a definite order. Dr. Sampson presented a theory for the probable origin of the Sudbury ore deposits, based on the character and location of the ore deposits in the basin and a microscopic study of the ores. The talk was illustrated by means of charts, sketches and maps. A rising vote of thanks was tendered to the speaker for his highly instructive lecture.

W. H. FLACK, *Secretary*

Academy of Natural Sciences of Philadelphia, January 7, 1932

A stated meeting of the Philadelphia Mineralogical Society was held on the above date, with Dr. Cajori presiding. Thirty-six members and seventeen visitors were present.

Dr. Joseph L. Gillson addressed the society on "Post-Consolidation Mineralization in Igneous Rocks." Reviewing early work on the subject, Dr. Gillson pointed out that Rosenbusch had stated the rule that most basic non-silicate minerals crystallize first, followed by the minerals low in silica. Recent work by various Scandinavian and American petrographers indicated that these supposed earlier minerals may have formed later by replacement of the silicates after the rocks had become quite solid. He cited the Engles Copper mine in California as an example. Earlier writers had considered this deposit of bornite and chalcopyrite to have crystallized from a molten magma, but later investigators believe it to be essentially a replacement deposit. Dr. Gillson described a deposit of ilmenite at Bay St. Paul, near Quebec, which he had mapped with the aid of a Hotchkiss Dip Needle. Study of diamond drill cores showed that the ilmenite had replaced minerals in an already solid anorthosite. Sapphirine was found with the ilmenite. Endomorphism and exomorphism at the contact of quartz monzonite and limestone near Pioche, Nevada, was described and the occurrence of szaibelyite and ludwigite there was noted. A rising vote of thanks was tendered to Dr. Gillson for his instructive talk.

WILEY H. FLACK, *Secretary*

MINERALOGICAL SOCIETY OF SOUTHERN CALIFORNIA

The seventh meeting of the Mineralogical Society of Southern California was held on Monday, January 11, 1932, in the lecture hall of the Pasadena Public Library. Mrs. Gertrude S. McMullen of the Southwest Gem and Jewelry Co., of Los Angeles, spoke on "Gems."

The third trip of the Society took place on January 17 at the Palos Verdes Estates where barite crystals and Indian artifacts were obtained.

BOOK REVIEWS

A MANUAL OF DETERMINATIVE MINERALOGY WITH TABLES FOR THE DETERMINATION OF MINERALS BY MEANS OF 1, THEIR PHYSICAL CHARACTERS; 2, BLOWPIPE AND CHEMICAL PROPERTIES; 3, OPTICAL PROPERTIES. J. VOLNEY LEWIS, fourth edition, revised by A. C. HAWKINS. IX+230 pages. John Wiley & Sons, Inc., *New York*, **1931.** Price $3.00.

The fourth edition of this very well known text makes its appearance ten years after the third edition. (For a review of the third edition, see *Am. Mineral.*, **7**, p. 57, 1922.) The revision has been undertaken by the junior author who is associate professor of geology at Rutgers University. The arrangement of the material is similar to that followed in the earlier edition, although the authors state in the preface to the fourth edition that "In this work we are agreed that the following are the principal changes required: (1) to reduce to the minimum the repetitions in the tables for the determination of minerals by means of their physical properties; (2) to eliminate from the blowpipe tables a number of minerals that are so rare as to have no practical importance; (3) to add a chapter on optical methods . . . ."

The portion devoted to optical methods, however, is restricted to slightly more than three pages. Here the color, cleavage, crystallization and refractive indices are recorded for 64 non-opaque minerals. No attempt is made to discuss the theory involved or the technique employed in determining the indices of refraction. For this discussion the student is referred to other standard texts.

The fourth edition shows a decrease of 68 pages compared with the previous edition. This reduction in size has resulted largely through the elimination of over 90 mineral species from the blowpipe tables.

The book is up-to-date, is unusually free from typographical errors, and will continue, no doubt, to be one of the most popular texts in the field of determinative mineralogy, although in some quarters it will be regretted that the authors have deemed it desirable to make such a drastic cut in the number of minerals contained in the blowpipe tables.

W. F. H.

SNOW CRYSTALS. WILSON A. BENTLEY AND W. J. HUMPHREYS. McGraw-Hill Book Co., Inc., *New York*, **1931.** Price $10.00.

A few of the over 5,000 wonderful enlarged photographs of snow crystals taken by Mr. Bentley in Vermont for a period of over forty years, have become well known, being reproduced in part by many authors writing on many subjects. The permanent preservation of over 2,200 of the best of these, on 185 plates with a dozen to a page, each photograph being about 2 inches in diameter, is now assured by the present volume, sponsored by the generous gift of a friend of the *American Meteorological Society*. Eighteen additional plates contain smaller reproductions of snow crystals, and of frost, rime, ice, glaze, graupel, sleet, and dew.

The 21 pages of explanatory text, by W. J. Humphreys, with a selected bibliography, make most interesting reading. The exquisite beauty of the designs and traceries is very intriguing, as is also the deciphering of the various crystallographical forms.

W. T. SCHALLER

GEMS AND GEM MATERIALS, Edward Henry Kraus and Edward Fuller Holden. Second edition. x+260 pages, 325 figures. McGraw-Hill Book Co., *New York*, **1931**. Price $3.00.

This excellent and popular text is a revision of an earlier edition published by the same authors in 1925. While the order of presentation of the subject matter of the first edition has been retained the chapters have all been expanded and supplemented with additional diagrams and photographs. The statistical data also have been brought up-to-date. The revised text has been greatly enriched as the direct result of a trip abroad to important gem cutting centers by the senior author.

As in the earlier edition the subject matter is divided into two parts. Part 1, approximately one half of the book, is devoted to a general discussion of those properties which are essential to an appreciative understanding of gems. Part 2 contains a detailed description of 60 minerals of inorganic composition and four (pearl, coral, amber, and jet) of an organic nature, that are now being used for gem purposes. Eleven conveniently arranged tables are included which summarize the properties of those minerals described in the text proper.

The style of presentation is direct, clear, and not too technical. The book is well adapted to serve either as a college text in this special field, or as a handy reference work for jewelers and those with an active interest in gems and gem materials.

A. J. Walcott

TEACHING FELLOWSHIP IN MINERALOGY

A teaching fellowship in mineralogy has been established at Stanford University. This fellowship is open to graduate students who intend to specialize in mineralogy and preference will be given to those who have had one year of graduate work. The chief duty of the fellow is to assist in laboratory instruction. Not more than eight or nine hours work a week will be required. The amount of the fellowship is $750.

Application for the year 1932–33, accompanied by testimonial letters, should be made to Professor A. F. Rogers, Box 87, Stanford University, California.